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Investigation of Interactions of U(VI) with Bacteria by Laser Spectroscopic Methods

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Bacteria are omnipresent in natural environments. They may play a role in the immobilization or transportation of actinides in aquifers. For example, the gram-positive *Bacillus sphaericus* was found to take up relatively large amounts of hexavalent uranium and plutonium [1]. This study by Panak et al. also indicated that the uptake occurs extracellularly via phosphate-containing cell structures like teichoic acids. We investigated in detail the nature of the functional groups involved in this uranium binding process by employing time-resolved laser-induced fluorescence spectroscopy (TRLFS) and Raman spectroscopy. In addition to living cells, we also investigated spores, intact dead cells and decomposed cells. By comparing fluorescence spectra of U(VI) interacting with living cells, spores, and intact dead cells to U(VI) adenosine monophosphate (AMP), we found very similar spectra for all these complex species. The AMP resembles very well the structure of teichoic acids with a phosphate group directly bound to an organic rest. U(VI), in contact with decomposed cells, shows a very different fluorescence spectrum than U(VI)-AMP. The spectrum is nearly identical to the spectrum of U(VI) that was precipitated with NaH_2PO_4 at the same pH than for the bacterial studies. Raman spectra revealed that the decomposition of the bacteria leads to enzymatic production of $H_2PO_4^-$. This increases the immobilization of U(VI) compared to the immobilization by living cells. In addition to sorption and decomposition, the natural bacterial metabolism can express complexing agents (phosphates or organic chelators). We investigated this with gram-negative *Pseudomonas aeruginosa* that were genetically engineered to over express phosphate. The kinetics and the mechanisms of the interaction of U(VI) with the released phosphate were studied by spectroscopy. We observed quantitative precipitation of U(VI) phosphate. In contrast, *P. aeruginosa,* not induced to express phosphate, does not change the fluorescence of U(VI) and therefore, it can be concluded that no significant interaction of natural metabolic byproducts of these bacteria with U(VI) occurs under the given conditions.

[1] Panak, P.; Raff J., S.; Selenska-Pobell, S.; Geipel, G.; Bernhard, G.; Nitsche, H., Radiochim. Acta 88, 71-76, 2000.

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